

ROOSEVELT (J. West)

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Result of Heredity and
Natural Selection.

BY

J. WEST ROOSEVELT, M. D.,

Visiting Physician to Bellevue Hospital, Attending
Physician to the Roosevelt Hospital,
New York.

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ACQUIRED IMMUNITY FROM CERTAIN INFECTIOUS DISEASES A RESULT OF HEREDITY AND NATURAL SELECTION.

BY J. WEST ROOSEVELT, M. D.,

VISITING PHYSICIAN TO BELLEVUE HOSPITAL,
ATTENDING PHYSICIAN TO THE ROOSEVELT HOSPITAL, NEW YORK.

THE various theories which have been advanced in explanation of the protection afforded by one attack of certain infectious diseases from subsequent attacks may be summarized as follows :

1. The pathogenic micro-organism is assumed to exhaust the supply of some substance present in the bodies of unprotected people, which substance is necessary for the nourishment of the parasite, and which, once removed by it, is not reproduced by the body. This is called "the exhaustion theory."

2. The micro-organism is thought to produce within the body some substance inimical to its own existence, and this antidotal substance, once formed, is not destroyed or excreted by the body. This is called "the antidote theory."

3. It is assumed that in a successful struggle with the invading bacteria the body cells acquire an increased

strength—become educated, one might say—and thus are able to destroy the enemy. This new strength they transmit to their descendants, so that the body is better able than before to repel subsequent invaders. Thus is established “tolerance” to the poison, as it is maintained.

The first theory may be regarded as untenable for several reasons, among which are the following, which seems to me to be fatal: If we accept it we must believe that Nature has provided man with a number of different substances which can have no conceivable use other than that of providing food and accommodation for pathogenic micro-organisms. These hypothetical substances are evidently not needed by the human body, since, *ex hypothesi*, bacteria remove them and they are not reproduced; yet the patient recovers entirely, and is not at all the worse for his illness. It would be hard to believe that this could be the case if provision were only made for the growth and nutrition of some *one species of germ*; but when we are alled upon to believe that the majority of mankind come into the world with a separate and distinct “substance” suited to the needs of the micro-organisms of small-pox, measles, scarlatina, chicken-pox, vaccinia, yellow fever, and a number of other diseases, the imagination is staggered and the reason revolts against such a preposterous idea. In a sense which will be indicated in another part of this paper, and which was not in the minds of its inventors, it may be said that there is some truth in the theory.

A certain degree of plausibility is lent to the antidotal hypothesis by the fact that, like all living things, bacteria produce by their own vital processes substances which, if sufficiently concentrated, are fatal to the producers. The great objection to it is that we know of no organic compound which is not excreted or destroyed by the body within a short time after its introduction into the system.

This makes it hard to conceive that any permanent protection can be afforded by bacterial action.

Of the three explanations suggested—the third, that of acquired tolerance—is nearer to the truth than the others, yet it does not altogether satisfy the mind. While it is free from the objections which apply to the others, it seems to me weak in one important respect. It is perfectly logical to assume that the power of resistance existing in a body-cell should be transmitted to its descendants, in accordance with the laws of heredity; but it is an assumption hardly warranted by experience or observation of other biological phenomena which ascribes to cells the power of acquiring and transmitting peculiar resisting powers during a period of stress such as must exist under conditions which obtain in the infectious diseases. It seems to be improbable that such should be the result of their fight.

To me it seems that the objections to the theory vanish if we apply the law of the survival of the fittest to the problem as well as the law of heredity. Let it be supposed that the feebler cells concerned in the struggle are for the most part killed. When recovery takes place the body will resume its original functional activity, but it will contain descendants of the cells originally strong enough to destroy the poison of the particular disease through which it has passed. Naturally the qualities of the parent cells are transmitted to their offspring. It is not so much by reason of new powers acquired by the stronger as by reason of the destruction of the weaker cells that immunity is afforded. This is much more in accord with Nature's methods as actually observed in the whole domain of biology. She seems to prefer to slay the weak rather than to leave them to transmit their weakness to others. The strong survive because of their strength, and in the end this is a benefit, for it tends to perpetuate and improve the

species and elevate the type which composes the majority of such species. In the long run it is far better that, relatively speaking, a few individuals should suffer and perish than that the whole number should do so at a later day. The survival of the fittest cells in the human body preserves the whole body from danger, if the theory of immunity set forth in this paper be true. Living cells then form the "substance" assumed in the "exhaustion theory" to be destroyed and never reproduced.

The evidence of its truth is largely derived from a consideration of the action of certain laws of Nature upon living organisms of complex structure—viz., animals and plants. It is therefore not to be regarded as entirely trustworthy. Reasoning by analogy is not true inductive reasoning; it is not based upon observed facts. Analogical evidence should be regarded by the scientist very nearly as circumstantial evidence is regarded by the lawyer. The latter can not be considered as approaching in value the testimony of trustworthy eye-witnesses, but its importance increases with each additional demonstrated fact which tends to show that a certain allegation is *probably correct*. When a sufficient number of facts have been presented in court, which, although they do not directly prove a case, make it extremely probable that certain events have occurred (as the lawyers express it, "show its probability beyond reasonable doubt"), circumstantial evidence amounts almost to proof, and has been regarded by the courts as actually proof. This should be the position of the scientist in respect to any theory which does not rest upon indisputable demonstration. The theory must explain all the known phenomena, and it must conflict with none of them. If based upon analogy, the closer and more evident the analogy, the more probable the theory. As time goes on and new observations are made in the light of more extended

knowledge, each one which accords with the theory increases the probability of its truth. When all known phenomena confirm it and *no single one fails to agree with it*, it may be considered as proved. It matters not whether the hypothesis was based upon fact or fancy.

It seems to me that this hypothesis is a rational explanation of the immunity conferred by attacks of the diseases under discussion. The fact that attacks of some acute infectious disorders do not diminish the susceptibility to infection does not, as I think, conflict with it. The reasons which justify the last statement will be given in another paper. For the present it is desired only to give very briefly an outline of this theory in its relation to certain others.

If the doctrine of phagocytosis is correct—if the disease process is a direct conflict between the phagocytes and the invading germs—then surely the weaker cells must perish, and, when the struggle is over, the body must find in the descendants of the stronger a safeguard against subsequent invasions. If it is by chemical substances produced within the body that the bacteria are overcome, the theory is perfectly reasonable. The bactericide necessarily is a product of cell activity; it is the direct or indirect action of the living tissue elements which determines the constitution of all the secretions and excretions. The blood plasma is no exception. If the latter contains as one of its normal constituents something toxic to certain forms of bacteria when present in sufficient amount, it is because some living cells produce it, as part of their life work. If the presence of the germ determines the production of such a substance, not previously existing in the plasma, it is still by cell activity that it is made. If recovery depends upon speedy elimination of the bacteria or some product of their growth, or something necessary for their nourishment,

again it must be accomplished by body cells. It might be that the micro-organisms of some diseases can only flourish by killing certain cells, directly or indirectly. Whatever be the method of attack or defense, the struggle is between germ and cell. The living tissue elements which are least able to withstand the stress of the conflict must succumb sooner than their stronger fellows; it matters not whether the weakness results from lack of sufficient destructive power as a phagocyte, or of sufficient power to produce an unusual quantity of some bactericide, or of adaptability to changed environment sufficient to manufacture some offensive or defensive substance different from that previously produced, or to withstand the deleterious effects of some product of bacterial life, or to remove some substance necessary for bacterial nourishment, or to do any work in the fight of any sort.

It may be objected that there is no proof that cells inherit qualities possessed by their ancestors. There is no direct proof; but to deny the fact would be equivalent to asserting that the whole is not equal to the sum of all its parts, for the hereditary peculiarities of animals are admitted, and animals are composed of multitudes of cells. If the latter do not inherit and transmit certain peculiarities, how can the former? If spermatozoon and ovum are able (as they unquestionably are) to influence so powerfully the development of the entire body as to cause physical or mental characteristics to recur generation after generation, it is impossible to conceive that this result can be produced unless *every generation* of their descendants (the body cells) receives and transmits hereditary traits.

It seems equally inconceivable that the law of the survival of the fittest, which is of universal application throughout the whole animal and vegetable world to each individual animal or vegetable of every species, should fail

to apply to every cell forming part of these individuals. No reasonable explanation can be (or, at all events, has been) adduced of the existence of such an anomaly in Nature.

It is a much more plausible supposition that qualities already possessed congenitally by the cells should be transmitted to descendants than that those acquired in a short, fierce struggle should be transmitted. Indeed, the possibility of the transmission of acquired traits is denied by some biologists. Of the congenital traits there is no doubt.

Of this theory it may be said, at least, that it is very fascinating. Is it not also suggestive and plausible? Is it not worthy of consideration as a working hypothesis, if nothing more? In another paper I shall discuss in detail the application of it to a number of diseases, and also to the protective effects of inoculations with attenuated virus and with vaccine.



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